

WHAT IS CLAIMED IS:35
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1. An apparatus for modifying an electrical audio signal for input to a sonic reproduction device characterized by a plurality of individual responses which in combination define an overall response for the sonic reproduction device, each individual response comprising at least one of a frequency, time, phase or transient response, said apparatus comprising:
 - 5 a plurality of modification filters having modification responses that simulate the plurality of individual responses, the modification filters for receiving the electrical audio signal, modifying the electrical audio signal and providing the electrical audio signal to the sonic reproduction device; and
 - 10 a plurality of adjustable parameters, each associated with at least one of the modification filters for allowing adjustments to the responses of the modification filters;
 - wherein the adjustments create a plurality of individual conjugate responses, each individual conjugate response associated with at least one of the plurality of
 - 15 individual responses.
2. The apparatus of claim 1 wherein the plurality of individual responses of the sonic reproduction device are related to at least one of mechanical, acoustic and electromagnetic behavior of the sonic reproduction device.
3. The apparatus of claim 1 wherein the filters are defined by digital signal processes.
4. The apparatus of claim 1 wherein the filters are defined by analog circuitry.
5. The apparatus of claim 1 wherein the plurality of modification filters are non-interacting.
6. The apparatus of claim 1 wherein the plurality of modification responses combine to form an overall response that is a conjugate to the overall response for the sonic reproduction device.

7. The apparatus of claim 1 wherein at least one of the modification filters comprises a cut-off filter and the parameters for adjusting the frequency response of the cut-off filter comprise peak frequency, amplitude and Q parameters.

8. The apparatus of claim 7 wherein the peak frequency, amplitude and Q parameters modify the frequency response of the cut-off filter in at least one of the low and high frequency ranges.

9. The apparatus of claim 1 wherein at least one of the modification filters comprises a constant slope equalizer and the parameters for adjusting the frequency response of the constant slope equalizer comprise crossover frequency and boost shelf parameters.

10. The apparatus of claim 9 wherein the crossover frequency and boost shelf parameters modify the frequency response of the constant slope equalizer in at least one of the low and high frequency ranges.

11. The apparatus of claim 1 wherein at least one of the modification filters comprises a parametric notch filter and the parameters for adjusting the frequency response of the parametric notch filter comprise notch frequency, amplitude and Q parameters.

12. The apparatus of claim 1 wherein at least one of the modification filters comprises a parametric notch-boost filter and the parameters for adjusting the frequency response of the parametric notch-boost filter comprise notch frequency, amplitude and Q parameters.

13. A sound compensation system for altering an electrical audio signal for input to a sonic reproduction device having associated behavioral characteristics, said system comprising:

a model of the sonic reproduction device having a plurality of filters that simulate at least one of the behavioral characteristics of the sonic reproduction device, each filter having an associated response that combine to define an overall response

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for the model, each response comprising at least one of a frequency, time, phase or transient response; and

- 10 a controller that modifies the response of each of the plurality of filters to transform the filter into a conjugate filter having a responses that is a conjugate to the original response of the filter.

14. The system of claim 13 wherein the behavioral characteristics are defined by individual components of the sonic reproduction device

15. The system of claim 13 wherein the behavioral characteristics are defined by groups of individual components of the sonic reproduction device

16. The system of claim 13 wherein the filters are defined by digital signal processes and the controller comprises a computer

17. The system of claim 13 wherein the filters are defined by analog circuits and the controller comprises adjustable circuit components

18. The system of claim 13 wherein the sonic reproduction device comprises a speaker and at least one of the plurality of filters comprises at least one associated adjustable parameter and the value of the parameter is calculated based on physical characteristics of the speaker.

19. The system of claim 18 wherein the physical characteristics of the speaker comprises at least on of cone and coil mass, air volume, mechanical compliance, radiating area, damping, moving mass and motor characteristics.

20. The system of claim 13 wherein the sonic reproduction device comprises a speaker and at least one of the plurality of filters comprises at least one associated adjustable parameter and the value of the parameter is derived from a standard speaker model.

21. The system of claim 13 wherein at least one of the plurality of filters has at least one associated adjustable parameter and the value of the parameter is determined experimentally using standard test measurements.

22. The system of claim 13 wherein the controller is configured such that an adjustment in the setting of one parameter modulates the setting of at least one other parameter.

23. The system of claim 22 wherein the sonic reproduction device comprises a speaker and the one parameter that modulates the at least one other parameter relates to the magnet structure and voice coil of the speaker.

24. The system of claim 13 wherein the controller monitors the program conditions at the sonic reproduction device and sets at least one of the parameter values based on the program conditions.

25. The system of claim 24 wherein the program conditions comprise at least one of volume control settings, program level and bass content.

26. The system of claim 13 wherein one of the filters comprises a weighted compensation notch filter.

27. The system of claim 26 wherein the filter comprises a single-tuned weighted compensation notch.

28. The system of claim 26 wherein the filter comprises a double-tuned weighted compensation notch.

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29. A sound system comprising:
a sonic reproduction device having associated mechanical, acoustic and electromagnetic behavioral characteristics;
a source for outputting an electrical audio signal to a model of the sonic reproduction device, the model having a plurality of filters that simulate at least one of the mechanical, acoustic and electromagnetic behavioral characteristics of the sonic

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10 reproduction device, each filter having an associated response comprising at least one of a frequency, time, phase or transient response, the model outputting the electrical audio signal to the sonic reproduction device; and

a controller that modifies the responses of the filters to transform the model into a conjugate model having a plurality of filters with responses that comprise conjugates to the original response of the filter.

30. The system of claim 29 wherein the filters are defined by digital signal processes.

31. The system of claim 29 wherein the filters are defined by analog circuitry.

32. The system of claim 29 wherein the plurality of filters are non-interacting.

33. The system of claim 29 wherein at least one of the filters comprises a cut-off filter and modifications to the frequency response of the cut-off filter comprise adjustments to peak frequency, amplitude and Q.

34. The system of claim 29 wherein at least one of the filters comprises a constant slope equalizer and modifications to the frequency response of the constant slope equalizer comprise adjustments to crossover frequency and boost shelf.

35. The system of claim 29 wherein at least one of the filters comprises a parametric notch filter and modifications to the frequency response of the parametric notch filter comprise adjustments to notch frequency, amplitude and Q.

36. The system of claim 29 wherein at least one of the filters comprises a parametric notch-boost filter and modifications to the frequency response of the parametric notch-boost filter comprise adjustments to notch frequency, amplitude and Q.

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37. A method for modifying an electrical audio signal for input to a sonic reproduction device characterized by a plurality of individual responses which in combination define an overall response for the sonic reproduction device, each individual response comprising at least one of a frequency, time, phase or transient response, said method comprising the steps of:
- 5 simulating the plurality of individual responses with a plurality of filters;
 adjusting the responses of the plurality of filters such that, for each filter, the adjusted response comprises a response that is a conjugate to one of the individual responses;
- 10 inputting the electrical audio signal to the filters.

38. The method of claim 37 wherein the plurality of individual responses of the sonic reproduction device are related to at least one of a mechanical, acoustic and electromagnetic behavior of the sonic reproduction device.

39. The method of claim 37 wherein the plurality of filters are non-interacting.

40. The method of claim 37 wherein the plurality of adjusted responses combine to form an overall response that is a conjugate to the overall response for the sonic reproduction device.

41. The method of claim 37 wherein at least one of the filters comprises a cut-off filter and the step of adjusting the frequency response of the cut-off filter comprises the step of setting at least one of peak frequency, amplitude and Q.

42. The method of claim 37 wherein at least one of the filters comprises a constant slope equalizer and the step of adjusting the frequency response of the constant slope equalizer comprises the step of setting at least one of crossover frequency and boost shelf.

43. The method of claim 37 wherein at least one of the filters comprises a parametric notch filter and the step of adjusting the frequency response of the

parametric notch filter comprises the step of setting at least one of notch frequency, amplitude and Q.

44. The method of claim 37 wherein at least one of the filters comprises a parametric notch-boost filter and the step of adjusting the frequency response of the parametric notch-boost filter comprises the step of setting at least one of notch frequency, amplitude and Q.

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45. A method of altering an electrical audio signal for input to a sonic reproduction device having associated behavioral characteristics, said method comprising the steps of:

5 simulating at least one of the behavioral characteristics of the sonic reproduction device with a plurality of filters, each filter having an associated response comprising at least one of a frequency, time, phase or transient response; and

 for each of the filters, modifying the response of the filter to transform the filter into a conjugate filter having a response that comprises a conjugate to the original response of the filter.

46. The method of claim 45 wherein the behavioral characteristics are defined by individual components of the sonic reproduction device.

47. The method of claim 45 wherein the behavioral characteristics are defined by groups of individual components of the sonic reproduction device.

48. The method of claim 45 wherein the sonic reproduction device comprises a speaker and at least one of the plurality of filters has at least one associated adjustable parameter and the step of modifying the response of the filter comprises the steps of:

5 calculating the value of the at least one adjustable parameter value based on the physical characteristics of the speaker; and

 setting the parameter to the calculated value.

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49. The method of claim 48 wherein the physical characteristics of the speaker comprises at least one of cone and coil mass, air volume, mechanical compliance, radiating area, damping, moving mass and motor characteristics.

50. The method of claim 45 wherein the sonic reproduction device comprises a speaker and at least one of the plurality of filters has at least one associated adjustable parameter and the step of modifying the response of the filter comprises the steps of:

- 5 deriving the at least one adjustable parameter from a standard speaker model;
and
setting the parameter to the derived value.

51. The method of claim 45 wherein at least one of the plurality of filters has at least one associated adjustable parameter and the step of modifying the response of the filter comprises the steps of:

- 5 determining the at least one adjustable parameter experimentally using
standard test measurements; and
setting the parameter to the determined value.

52. The method of claim 48, 50 or 51 further comprising the step of modulating the setting of at least one parameter in response to the setting of another parameter.

53. The method of claim 48, 50 or 51 further comprising the steps of:
monitoring at least one program condition at the sonic reproduction device;
and
setting at least one of the parameter values based on the at least one program condition.

54. The method of claim 53 wherein the program conditions comprise at least one of volume control settings, program level and bass content.